APPLICATION FOR PATENT

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Title: SATELLITE COMMUNICATION CARD

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates generally to satellite communications, and specifically to personal computer cards for use in satellite communication by radio frequency.

Very small aperture terminals (VSATs), comprising a small satellite dish or flat-plate antenna and appropriate modulating and demodulating hardware coupled to a dedicated computer, are known in the art as means for transferring data directly between locations via a satellite. VSATs are typically used for data exchange in point-to-multipoint data networks, such as automated teller machines (ATMs) and point-of-sale systems, and may also be used for other types data transfer such as direct video broadcasting (DVB).

Personal computer cards capable of receiving signals directly from satellite transmissions are also known in the art. For example, Gilat Satellite Networks Ltd., of Petah Tikva, Israel, produces a satellite receiver card called "SkySurfer" for installation in a personal computer. The card plugs into an industry-standard PCI bus, and is designed to receive direct video broadcasts using a coaxial cable connected to a dish antenna.

European patent application EP 0-734-140, whose disclosure is incorporated herein by reference, describes a portable satellite communications terminal based on a personal computer (PC) . An interface card is inserted into the PC, enabling the PC to

communicate with a satellite antenna through an external modulation/demodulation unit followed by an external radio frequency (RF) subsystem coupled to the antenna.

SUMMARY OF THE INVENTION

It is an object of some aspects of the present invention to provide apparatus and methods for signal transmission from a personal computer.

It is a further object of some aspects of the present invention to provide apparatus and methods for communication between a personal computer and a remote transmitter/receiver via satellite.

In preferred embodiments of the present invention, a plug-in communications card in a PC generates modulated radio frequency (RF) signals, which are conveyed via a coaxial cable to a power amplifier and an upconverter of an antenna system, for transmission via satellite. The card comprises a power connector which enables the power from a DC power supply to be conveyed via the card and the cable to the antenna system. Most preferably, the power supply is external to the computer. Thus signals and power to operate the upconverter and the power amplifier are transferred on the coaxial cable. The card plugs into an industry-standard bus in the PC, which controls the card's operation and conveys data to the card for transmission via the satellite.

The communications card comprises a frequency synthesizer for generating and transmitting the RF signals, preferably in a range between about 950 MHz and 3000 MHz or in any sub-range therein. The signals are conveyed via the coaxial cable to the upconverter and the power amplifier, which are preferably contained in the antenna system. The power level of the signals from the synthesizer is preferably of the order of 1 mW. The upconverter and power amplifier convert the RF signals to

higher frequencies and higher power, for transmission by an external dish or flat-plate antenna. Most preferably, the signals are modulated by a keying modulator, whose modulation scheme is user-selectable according to any standard modulation system, under control of the PC.

Before modulation, the signals are encoded by an encoder, also under the control of the PC, preferably using forward error correction (FEC) encoding or concatenated coding.

In some preferred embodiments of the present invention, the communications card comprises a fast interface bus connector, which enables the communications card to communicate directly with one or more other cards without needing to go through the PC bus. Preferably, a fast parallel data bus is used as the fast interface bus. Most preferably, the communications card uses the fast interface bus to communicate directly with a receiver card, having a corresponding fast interface bus connector, installed in the PC. When the receiver card is present, the fast interface bus may be used to transfer a synchronizing clock recovered from signals received by the receiver card, and transmissions from the communications card may be timed accordingly, as described, for example, in U.S. Patent Application 09/135,502, entitled, "Bi-Directional Communications Protocol," to Ben-Bassat et al., which is assigned to the assignee of the present patent application and incorporated herein by reference.

There is therefore provided, in accordance with a preferred embodiment of the present invention, a transmitter card for a personal computer, including:

a circuit board which plugs into the personal computer and which is coupled to exchange data via an industry-standard bus in the personal computer; and

radio frequency modulation circuitry on the circuit board, which receives the data and transmits radio frequency signals responsive thereto.

Preferably, the circuitry includes a frequency synthesizer generating the radio frequency signals.

Preferably, the frequency generated by the frequency synthesizer is set by a controller on the circuit board.

Alternatively, the frequency generated by the frequency synthesizer is set by conveying instructions via the computer bus.

Preferably, the card is coupled to an external antenna system, and includes a connector, through which a DC source external to the card powers the antenna system.

Preferably, the frequency modulation circuitry is coupled to convey the radio frequency signals to the antenna system via the connector.

Preferably, the modulation circuitry modulates the transmitted signals according to a predefined protocol in accordance with a command conveyed to the card via the industry-standard bus.

Alternatively, the modulation circuitry includes an encoder which encodes error correction into the transmitted signals according to a predefined protocol in accordance with a command conveyed to the card via the industry-standard bus.

Alternatively, the card includes an auxiliary connector through which the card is coupled to at least one other card located in the computer, such that signals pass between the cards without passing through the industry-standard bus.

Preferably, the signals are transmitted to a satellite.

There is further provided, in accordance with a preferred embodiment of the present invention, an RF communication card for a personal computer, including:

a circuit board which plugs into the personal computer and which is coupled to exchange data via an industry-standard bus in the personal computer;

RF circuitry on the circuit board, which receives the data and processes radio frequency signals responsive thereto; and

an auxiliary connector through which the card is coupled to at least one other card located in the computer, such that signals pass between the cards without passing through the industry-standard bus.

Preferably, the communication card conveys a synchronizing signal via the auxiliary connector.

There is further provided, in accordance with a preferred embodiment of the present invention, a satellite transceiver for a personal computer, including:

a transmitter card which plugs into the personal computer and which is coupled to exchange data via an industry-standard bus in the personal computer and which transmits radio frequency signals responsive to the received data;

a receiver card which plugs into the personal computer and which is coupled to transfer data via the industry-standard bus and which receives radio frequency signals and converts the received signals to data for transfer via the bus; and

an auxiliary bus directly connecting the transmitter card and the receiver card.

Preferably, the transmitter card and the receiver card include respective connectors coupling the cards to the auxiliary bus.

There is further provided, in accordance with a preferred embodiment of the present invention, a method for transmitting a radio frequency signal directly from a personal computer, including:

mounting a transmitter card in the personal computer;

conveying data to the card via an industry-standard computer bus in the personal computer; and

transmitting the radio frequency signal from the card responsive to the data.

Preferably, conveying data to the card includes determining a frequency band of the signal.

Alternatively, the method includes:

mounting a power connector on the card; and

powering an antenna system external to the card via the power connector.

Preferably, transmitting the radio frequency signal includes modulating the signal in accordance with a modulation scheme determined responsive to a command conveyed via the bus.

Alternatively, transmitting the radio frequency signal includes encoding an error correction onto the signal in accordance with an encoding scheme determined responsive to a command conveyed via the bus.

Alternatively, the method includes connecting the transmitter card to at least one other card via an auxiliary connector, such that signals pass between the cards without passing through the industry-standard bus.

Preferably, transmitting the signal includes transmitting the signal to a satellite.

There is further provided, in accordance with a preferred embodiment of the present invention, a method for transmitting and receiving signals between a satellite and a personal computer including:

coupling a transmitter card to an industry-standard bus in the computer;

transmitting radio frequency signals from the transmitter card responsive to data from the bus;

coupling a receiver card to the industry-standard bus;

receiving radio frequency signals in the receiver card responsive to data from the bus; and

coupling the transmitter and receiver cards together directly via an auxiliary bus separate from the standard bus.

Preferably, receiving radio frequency signals includes conveying a synchronizing signal from the receiver card to the transmitter card via the auxiliary bus.

The present invention will be more fully understood from the following detailed description of the preferred embodiments thereof, taken together with the drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic block diagram of a communications terminal coupled to an antenna system, in accordance with a preferred embodiment of the invention;

FIG. 2 is a schematic block diagram of a personal computer RF transmission card, in accordance with a preferred embodiment of the present invention;

FIG. 3 is a schematic block diagram of a personal computer RF transmission card coupled to a PC receiver card, in accordance with a preferred embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference is now made to Figure 1, which is a schematic block diagram of a communications terminal **10** coupled to an antenna system **70**, in accordance with a preferred embodiment of the present invention. In terminal **10** a transmitter card **25** or **60** is installed in a vacant slot of an industry-standard bus **45**, such as a PCI bus, comprising an address bus **46**, a data/control signal bus **48**, and a power bus **50**, as well as additional lines, of a personal computer **11**. The busses of the computer are in

communication with corresponding busses of the card, and the output of the card is fed to antenna system **70**. The operation of transmitter cards **25** and **60** is described in detail hereinbelow.

Preferably, computer **11** comprises the following standard components: a video display unit (VDU) **13**, a user interface device **15** comprising a mouse and/or a keyboard, a central processing unit (CPU) **19** such as an Intel Pentium processor, a memory **21** comprising volatile (generally RAM) memory and non-volatile memory, such as a hard disk, and a power supply **17**. Power supply **17** powers the above-mentioned standard components and the transmitter card. Preferably, personal computer **11** also comprises a receiver card **54**, receiving its input from antenna system **70**. Receiver card **54** is installed in a vacant slot of computer **11** and is connected thereby to bus **45**.

Preferably, antenna system **70** comprises the following industry-standard components: a dish or flat plate antenna **23**, an orthomode transducer **27**, a low noise block **29**, an upconverter **72**, and a power amplifier **12**. Transducer **27** directs signals received by antenna **23** to low noise block **29**, wherein the received signals are amplified and downconverted to a lower frequency, and are then transferred to receiver card **54**. Upconverter **72** converts transmitted signals from transmitter card **25** or **60** to a higher frequency range, typically a range in the Ku band, and the converted signals are then amplified in power amplifier **12**. The converted signals are transferred via transducer **27** for transmission by antenna **23**. Most preferably, power for upconverter **72** and amplifier **12** is supplied from a power supply **52** via transmitter card **25** or **60**, as described below.

As will be seen below, transmitter cards **25** and **60** are similar. The main difference between transmitter cards **25** and **60** is that transmitter card **25**

communicates with receiver card **54** exclusively via bus **45**, whereas transmitter card **60** also communicates with receiver card **54** via a fast interface bus connector, described below, that enables the exchange of data between transmitter card **60** and receiver card **54** without the delays associated with bus **45**.

Figure 2 is a schematic block diagram of transmitter card **25**, in accordance with a preferred embodiment of the present invention. Preferably, all active components of card **25** are powered from power bus **50**. A dedicated programmable main controller **26** controls the functioning of card **25**. Most preferably, controller **26** is a high performance integrated communications controller, such as a QUICC 68360 produced by Motorola Inc., of Phoenix, Arizona. Controller **26** is provided with a memory **35** for data storage. Controller **26** communicates with busses **46**, **48**, and **50** via a glue logic device **33** and a bus interface device **28**, such as a PLX9080, produced by PLX Technology Inc., of Sunnyvale, California. Controller **26** and other components on card **25** communicate with and are controlled by CPU **19** of personal computer **11**, via busses **46** and **48**.

Modulation circuitry **37** comprises frequency synthesizer **14** and associated circuits providing a baseband-modulated input thereto, as described further hereinbelow. Synthesizer **14** generates and transmits an RF signal, preferably in the range 950 MHz - 3000 MHz, or in any sub-range therein. Most preferably, synthesizer **14** is in a well-shielded and grounded enclosure, in order to substantially reduce noise transfer from the computer to the RF signal, and vice versa, as is known in the art. Preferably, synthesizer **14** is capable of supplying of the order of 1 mW of RF signal power into a connector **36**. Most preferably, connector **36** comprises a 75 ohm impedance F-type connector which in turn supplies the signal via a suitable coaxial cable to antenna system **70**.

To generate on the order of 1 watt of RF power, which is the power typically required for transmission of signals via satellite, system **70** generally requires on the order of 50 watts of DC power at 24 VDC. Preferably, the power is supplied by a DC power supply **52**, external to the card and to the computer, the power supply receiving its power directly from an AC line source **54**, preferably operating in the 100-240 VAC range. The DC power is fed to antenna system **70** via a suitable power connector **34** on card **25** and via connector **36**.

Synthesizer **14** generates a specific radio frequency for a chosen channel of communication, for example 1000 MHz, according to commands received from controller **26**. The radio frequency is modulated using baseband signal levels from a digital-analog converter **16**, so that the modulated signal output from the synthesizer is compatible with an industry-standard protocol. Preferably, converter **16** also comprises a low-pass baseband filter to smooth the signals produced during the conversion.

The baseband signals provided to converter **16** are generated by a keying modulator **40** and a forward error correction (FEC) encoder **42**, whose respective functions are described in more detail hereinbelow. Most preferably, the functions of keying modulator **40** and encoder **42** are realized in a single field programmable gate array (FPGA) **20**, such as a FLEX6000 produced by Altera Corporation of San Jose, California. FPGA **20** is programmed by main controller **26**, or alternatively from PC bus **46** and/or PC bus **48**, in accordance with instructions stored in memory **21** (Figure **1**). Alternatively, two or more field-programmable devices may be used to implement the modulator and encoder, and/or factory-programmed or hard-wired logic may be used for this purpose. Further alternatively, one or more application

specific integrated circuits (ASICs) may be used to implement the modulator and encoder.

Keying modulator **40** supplies modulation signals in a standard format, such as one of the phase shift keying (PSK) formats known in the art, for example MSK, BPSK, DPSK, QPSK, or OQPSK. The format may be chosen according to whatever protocol is required by a receiving station, such as a VSAT hub, that is to receive the signals from card **25**, and is loaded into FPGA **20** as described above. It will be understood that where the format needs to be changed, e.g., for transmission to a different receiving station, FPGA **20** may be reprogrammed by the PC, preferably by loading a suitable program into FPGA **20** from memory **21**. The reprogramming may be performed automatically according to a communications channel that is chosen, or may be performed via user interface **15** (Figure 1).

The data input to FPGA **20** is derived from the information to be transmitted, and is received by FPGA **20** from controller **26**. For example, the data may comprise IP packets transmitted on any suitable bus known in the art.

Encoder **42** generates an optional forward error correction (FEC) signal for encoding onto the transmitted signal, by one of the standard methods known in the art such as Viterbi, concatenated, Turbo, or Reed-Solomon coding. Typically, the FEC encoding adds some redundant information to the transmitted signal, for the purpose of improving signal recovery at the receiver. The method chosen is dependent on the requirements of the receiving station, and is programmable into FPGA **20** as described above.

Reference is now made to Figure 3, which is a schematic block diagram of a transmission card **60**, in accordance with a preferred embodiment of the present invention. Apart from the differences described below, card **60** is generally similar to

card **25** (Figure 2), and elements indicated by the same reference numerals in both card **25** and card **60** are generally identical in construction and operation. In addition to the elements of card **25**, card **60** comprises an auxiliary connector, to wit, a fast interface bus connector **41**, which is coupled to transfer signals to and from controller **26** via a receiver interface **62** and a first-in first-out (FIFO) buffer **31**. Preferably, interface **62** is a functional block contained in FPGA **20**. Connector **41** enables signals to be sent to and from other cards in the personal computer having similar fast interface bus connectors, without the delay and jitter introduced by standard PC busses.

Most preferably, connector **41** is connected by a cable **39** or mating connector to a similar connector **52** on receiver card **54** installed in the PC and is used to route data and synchronize the operation of the transmitter and receiver cards, for example, as described in the abovementioned U.S. patent application 09/135,502. Receiver card **54** comprises receiver circuitry **56**, described in detail hereinbelow, which communicates directly with connector 41, and also communicates with busses **46**, **48**, and **50**. Preferably, when the receiver and transmitter cards are communicating with a remote receiver/transmitter, such as a VSAT hub, using a slotted communications protocol, the receiver card transfers data to the transmitter card via connector **41**. Controller **26** recovers a synchronizing pulse from the data, and uses the synchronizing pulse to time the transmissions of card **60** according to the protocol being used.

Receiver circuitry **56** most preferably comprises a tuner **51**, an ASIC-based receiver **53**, and an MPEG2 demultiplexer and decoder device **59**. Tuner **51** receives incoming signals, typically digital video broadcast (DVB) signals, from Low Noise Block **29** of antenna system **70** (Fig. **1**) and divides the signals to I and Q components,

as is known in the art. ASIC-based receiver **53** demodulates and converts the I and Q signals to digital data, and transfers the data to device **59**. Most preferably, the data from ASIC-based receiver **53** is also transferred to connector **52** and from there to card **60**, as described hereinabove. Decoder **59** utilizes a RAM **57** to store interim data used in its operation. Tuner **51**, ASIC-based receiver **53**, and decoder **59** communicate with bus **45** via a bus interface **55**.

It will be appreciated that while the preferred embodiments described above refer specifically to satellite transmission, the transmitter card may be used to generate RF signals for terrestrial transmission, as well. It will thus be appreciated that the preferred embodiments are cited herein by way of example, and the full scope of the invention is limited only by the claims.